

Strait of Georgia Juvenile Herring Survey, September 2010

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Fisheries and Oceans Canada
Science Branch, Pacific Region
Pacific Biological Station
Nanaimo, British Columbia
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ABSTRACT

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A survey of juvenile herring was conducted in the Strait of Georgia during September 2010. Forty-seven stations were sampled throughout the Strait of Georgia following the ten core transects that have been sampled since 1990. The survey area extends from Trincomali Channel in the south to Smelt Bay in the north. Plankton tows were performed to determine food organism abundance in the study area.

RESUME

Thompson, M., Fort, C., and Schweigert, J. 2011. Strait of Georgia juvenile herring survey, September 2010. *Can. Manuscr. Rep. Fish. Aquat. Sci.* 2957: v + 34 p.

Une campagne de relevés portant sur les stocks de harengs juvéniles du détroit de Georgia a été effectuée septembre 2010. Des échantillons ont été prélevés dans 47 stations du détroit de Georgia situées sur les dix transects échantillonnés depuis 1990. La zone d'échantillonnage s'étendait du chenal Trincomali au sud à la baie de Smelt au nord. Des traits de plancton ont été effectués pour déterminer l'abondance de nourriture disponible dans la zone étudiée.



INTRODUCTION

Pacific herring (*Clupea pallasii*) are an important commercial and a vital forage species for many marine mammals, birds and other fish in British Columbia's coastal waters. Herring spawn principally on marine vegetation in the subtidal and upper intertidal zone between February and June, with peak spawning between March and April (Humphreys and Hourston 1978). Larvae hatch in two to three weeks, and disperse with surface currents, metamorphosing into juvenile or young-of-the-year herring at a length of ~25mm (Hourston and Haegele 1980). Herring are considered juveniles or immature until they are about three years of age and have joined the sexually mature spawning population (Hay and McCarter 1999). During daylight hours, juvenile herring congregate in schools, occasionally forming mixed aggregates with other pelagic species, close to shore near the bottom (Haegele 1997). At dusk, these fish migrate into surface waters to feed on plankton. During this time they are vulnerable to purse seine gear.

Purse seine surveys to determine the distribution and abundance of juvenile herring in the Strait of Georgia have been conducted annually since 1990, except for 1995 (Figure 1). The main objective of the survey was to estimate the density and relative abundance of the juvenile herring population as a potential indicator of recruitment before they have joined the spawning stock (Schweigert et. al. 2009). In addition to recruitment prediction, the surveys have contributed to a better understanding of the distribution, abundance, and ecological role of herring in the Strait of Georgia.

METHODS

The annual survey of juvenile herring in the Strait of Georgia in 2010 (Figure 2) followed the ten core sampling transects (1 – 6, 8 – 11); which are made up of 48 sampling stations and have been sampled consistently since 1990 (except 1995). These ten core transects have been used in juvenile herring recruitment prediction (Hay et. al. 2003). Originally, the sampling sites were chosen based on known historical herring spawning sites, and represent both nearshore and open water habitats (Haegele et. al. 2005). In 2010, sampling was conducted from September 12th to 28th (Table 1). Forty-seven core stations were sampled with station 1 on transect 4 (Henry Bay) skipped due to large amounts of jellyfish.

Fish Sampling

The 12 m, aluminum-hulled Fisheries Research Vessel *Walker Rock* was used for all fishing events. A 183 m long and 27 m deep purse seine net of knotless web, resulting in an area fished of ~2665 m², was used for all fishing events. The body of the net had 46 m of 22.2 mm mesh at the tow end followed by 91 m of 19.0 mm mesh, and the bunt end was 46 m of 9.5 mm mesh. The net fished to a depth of 10 m, and was able to retain fish greater than 20 mm in length. All sets were made after dusk when herring are feeding

near the surface. All sets were made "blind" at the pre-determined sampling stations. Five sets were completed per night, depending on location, and length of travel between transects and the marine weather forecast. For most sets, it was possible to land the entire catch for biological sampling. On occasion, it was not practical to land a large set in its entirety, so sub-sampling was necessary. When sub-sampling was required, a 40 kg tote was filled with randomly selected fish and retained for biological sampling. Several dipnet samples were taken from various parts of the net (catch) to make up the random sub-sample. The remainder of the set was released over the corkline, its size estimated as the number of totes released. The number of herring caught in each set was determined by dividing the total catch weight by the mean weight of sub-sampled herring. The number of other species caught was determined in the same manner (Tables 3 and 4). All fish retained for sampling were bagged and preserved in a 3.7 % seawater formalin solution, with the exception of large predator species (e.g. adult salmon and flatfish). These fish were individually measured in the field. All retained fish were later sampled in the laboratory at the Pacific Biological Station. From each set, 100 or more herring and all other fish species caught were identified, weighed and measured. If the set contained less than 100 herring, then all herring were weighed and measured. Consistent with standard practices, herring were measured to standard length, salmon to fork length and groundfish to total length; all to the nearest millimeter. All other fish species were measured to standard length.

Plankton Sampling

Twenty stepped oblique plankton tows were performed during the survey (Figures 3). The tows always were completed after dusk and immediately before the fishing events. A nearshore and offshore tow location was sampled for all transects. Dual 19 cm diameter bongo nets with 350 μ m mesh were used for sampling, resulting in 'left' and 'right' bongo plankton samples (only left samples were processed). The bongos were lowered to 20 m (10 m in shallow areas) and raised by an electric winch at a rate of 1 m every 15 sec (or 1 m every 30 sec for shallow areas). A General Oceanics® 2030R model flowmeter was attached to the left bongo to determine the volume of seawater filtered. Volume filtered was calculated using the following equation (McCarter and Hay 2002):

$$V = (A \cdot F \cdot K) / 999,999$$

where:

V = volume of water filtered through the plankton net (m^3)

A = area of net opening ($0.02835 m^2$)

F = number of revolutions recorded by the flow meter (m)

K = standard speed rotor constant for 7cm rotor (26,873)

Upon retrieval, the bongo nets were washed with a high pressure deck hose, and the samples preserved in 3.7 % seawater formalin.

In the laboratory, a volumetric splitter was used to reduce the sample size to a point where organisms could be conveniently counted and identified in a counting tray using a stereo microscope under 30X magnification. Sample splitting continued until a target size of roughly 300 organisms was reached (Thompson et al. 2003).

When possible, plankters were identified to the lowest taxonomic level. Copepods were identified to species. Densities for all plankters were determined and expressed as plankters/ m³.

RESULTS

Herring

Forty-seven stations were sampled from transects 1 – 6, 8 – 11. A total of 2091 herring were weighed and measured resulting in a length frequency distribution that was distinctly unimodal for age-0+ herring (Figure 4). Three length designations for the juvenile herring age-classes were produced:

0+ = herring less than or equal to 122 mm standard length

1+ = herring between 123 mm and 154 mm standard length

2+ and older = herring greater than or equal to 155 mm standard length

Age-0+ herring occurred in 80.9 % of the stations (Table 3). Thirty-eight of the forty-seven stations contained age-0+ herring. The mean length and weight for age-0+ herring was 96 mm and 12.38 g respectively. A total of 46388 age-0+ were caught for a total weight of 543.62 kg (Table 4).

Age-1+ herring occurred in 34.0 % of the stations (Table 3). Sixteen of the forty-seven stations sampled contained age-1+ herring. The mean length and weight for age-1+ herring was 134 mm and 36.65 g, respectively. A total of 347 age-1+ herring were caught for a total weight of 12.89 kg (Table 4).

Age-2+ herring occurred in 23.4 % of the stations (Table 3). Eleven of the forty-seven stations sampled contained age-2+ herring. The mean length and weight for age-2+ herring was 166 mm and 66.14 g, respectively. A total of 99 age-2+ herring were caught for a total weight of 6.68 kg (Table 4).

Length frequency histograms by transect location for all sampled herring are shown in Figure 5. Most transects were dominated by a single age-0+ age-class except French Creek (Transect 5) and Atrevida Reef (Transect 9) which included a mixture of all three herring age-classes. As in 2008 (Thompson et. al., 2009), Trincomali Channel (Transect 6) and Yellow Point (Transect 2) produced age-0+ herring smaller than the survey average. This is more than likely due to the variation in spawning times of herring above

and below Dodds Narrows. A length-weight relationship for all sampled herring from the survey showed a positive correlation coefficient (r^2) of 0.9824 (Figure 6).

Plankton

There were 24 categories of organisms identified in 20 plankton samples (Tables 5 and 6). An average of 15.317 m³ of water was filtered per plankton tow. *Paracalanus parvus*, *Calanus sp.* and *Corycaeus anglicus* copepods were the only category to occur in all samples. Calanoid copepods *Paracalanus parvus*, *Calanus sp.* and *Pseudocalanus sp.*, cyclopoid copepod *Corycaeus anglicus*, shrimp larvae occurred in >95% of the samples. More than 60% of all plankton biomass captured were calanoid copepod *Paracalanus parvus*, *Calanus sp.* and *Pseudocalanus sp.* and cladocerans (*Podon sp.* and *Evadne sp.*).

CONCLUSION

Forty-seven stations were sampled resulting in 18 different fish species recorded from purse seine sets. A total of 2091 herring were measured and weighed creating a bimodal histogram clearly representing age-0+, age-1+ juvenile herring. Twenty plankton tows were performed resulting in cladocerans (*Podon sp.* and *Evadne sp.*) and calanoid copepods; *Paracalanus parvus* and *Calanus sp.*, being the predominant organisms in numbers and biomass.

ACKNOWLEDGMENTS

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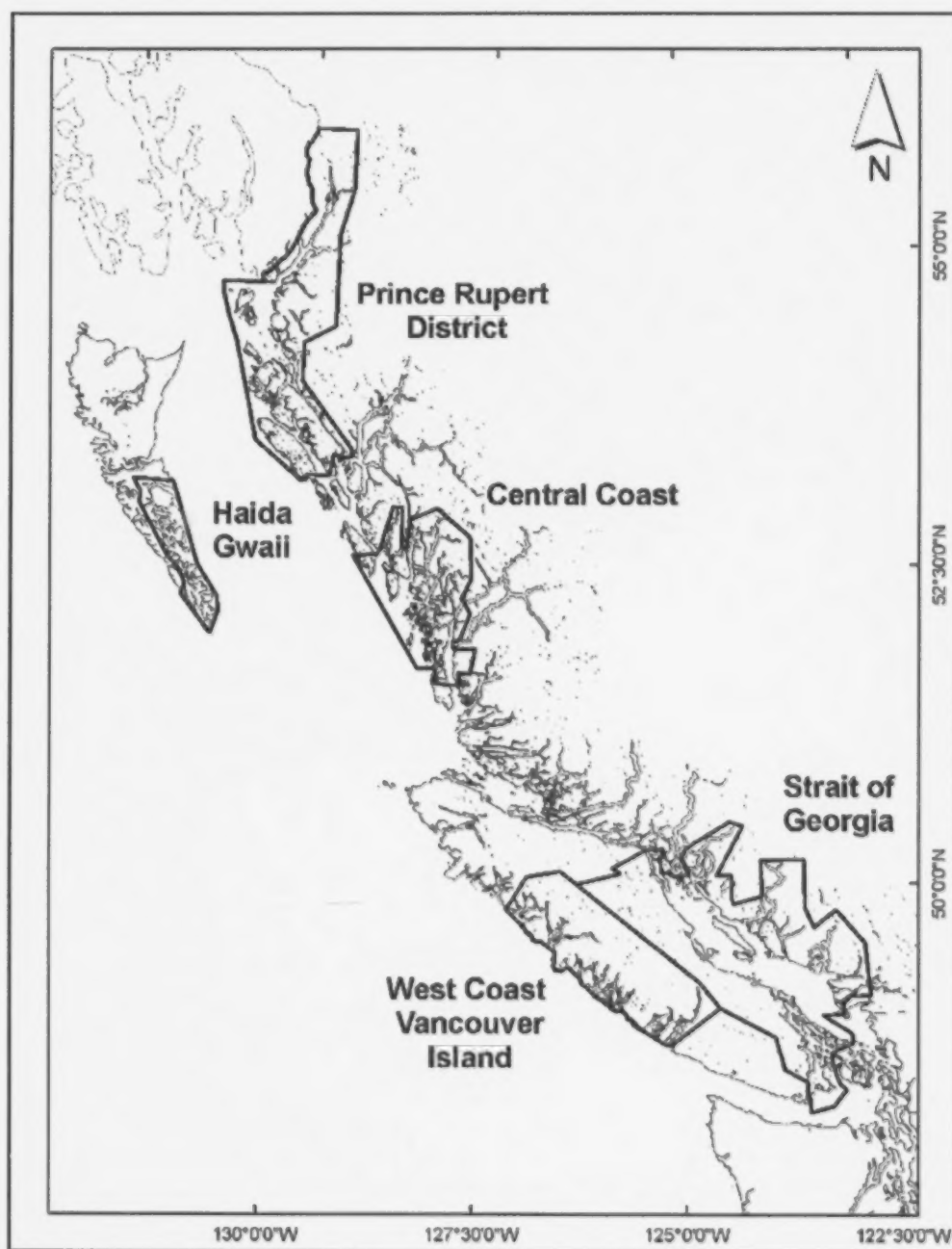


Figure 1. The five major British Columbia herring stock assessment areas.

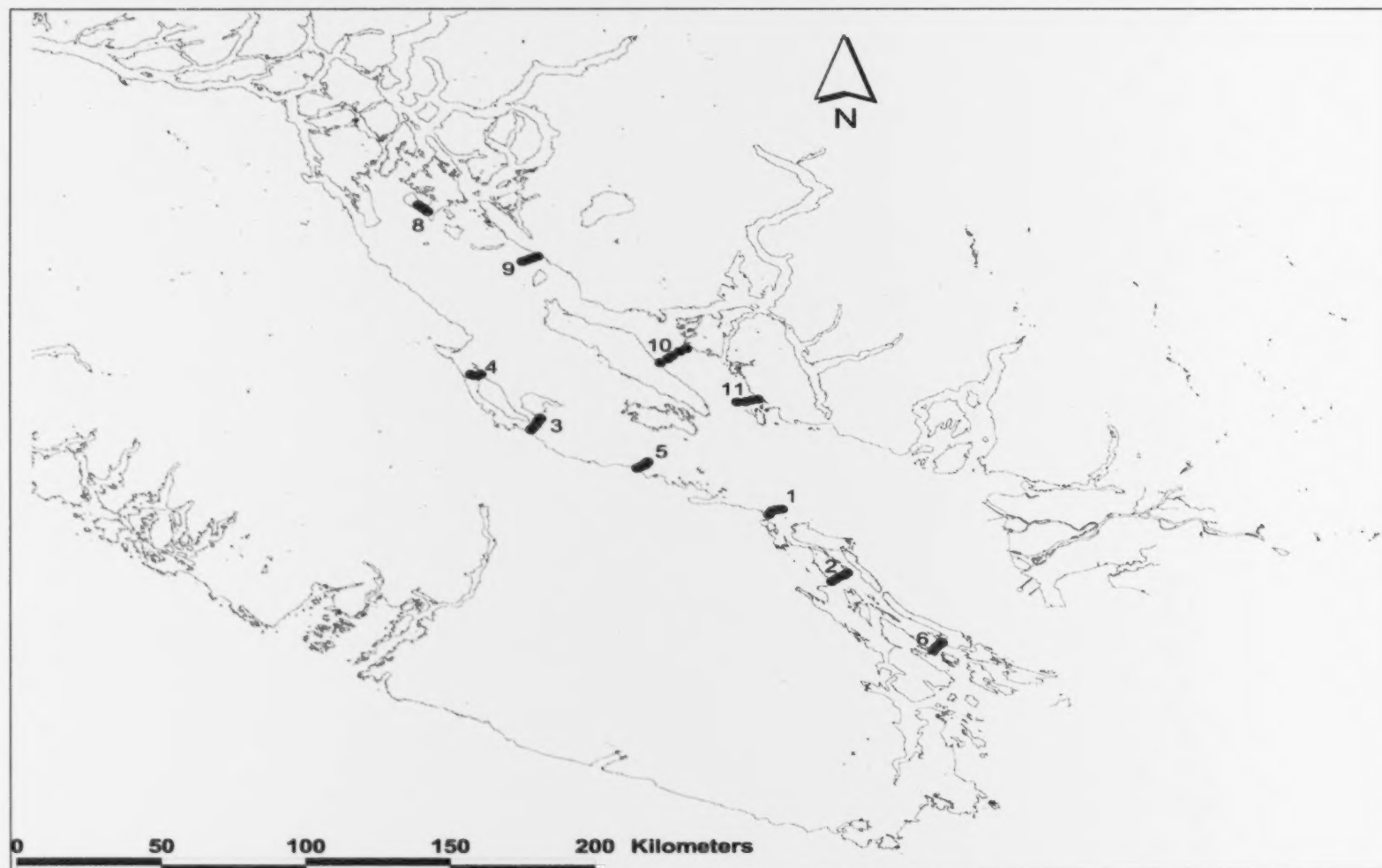


Figure 2. Purse seine set locations for the 2010 Strait of Georgia juvenile herring survey.

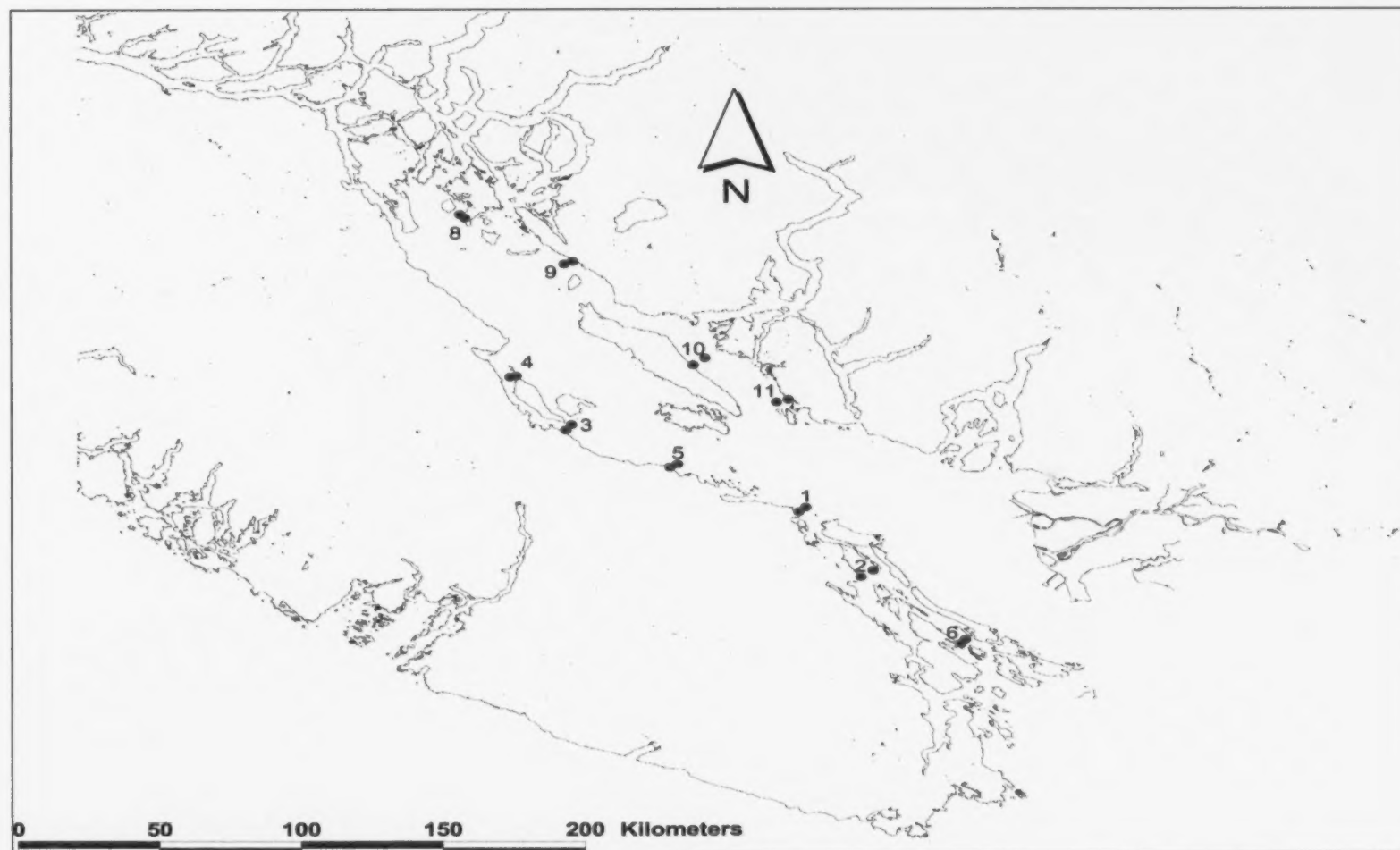


Figure 3. Plankton stations for the 2010 Strait of Georgia juvenile herring survey.

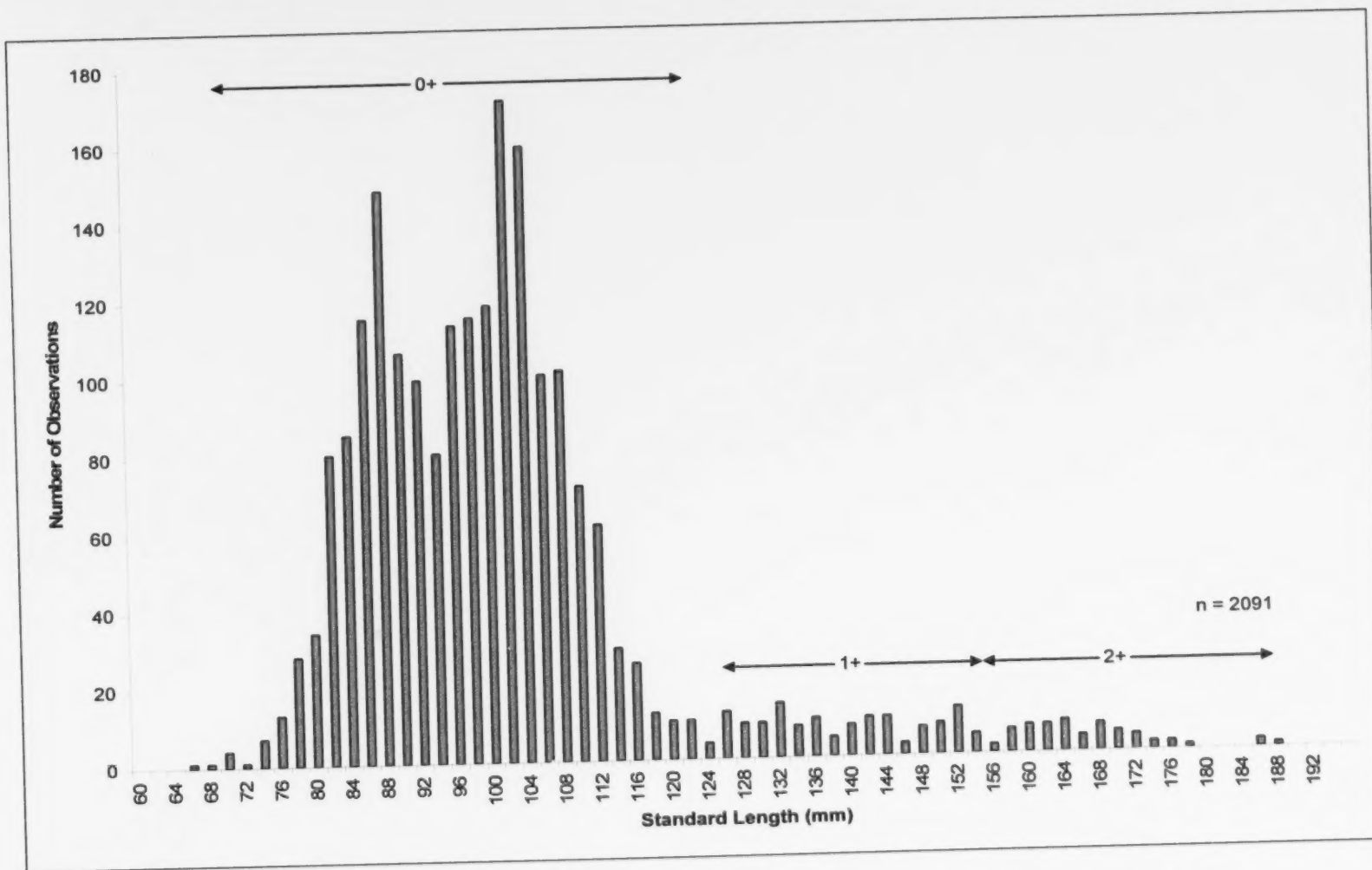


Figure 4. Length-frequency distribution for all herring sampled during the 2010 Strait of Georgia juvenile herring survey.

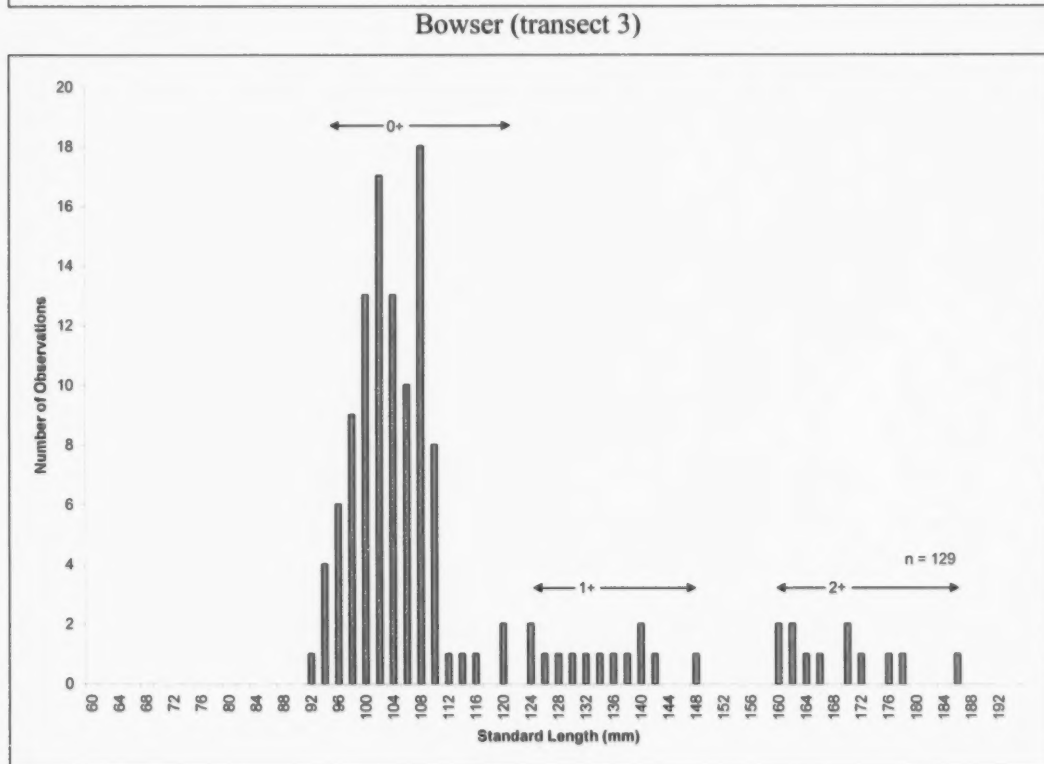
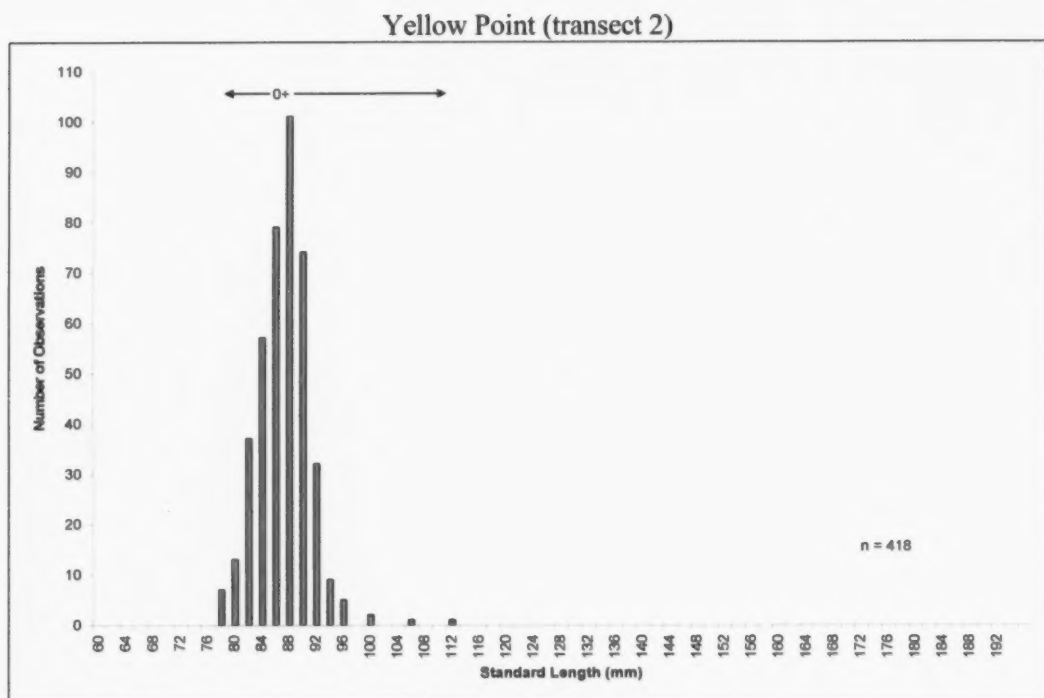
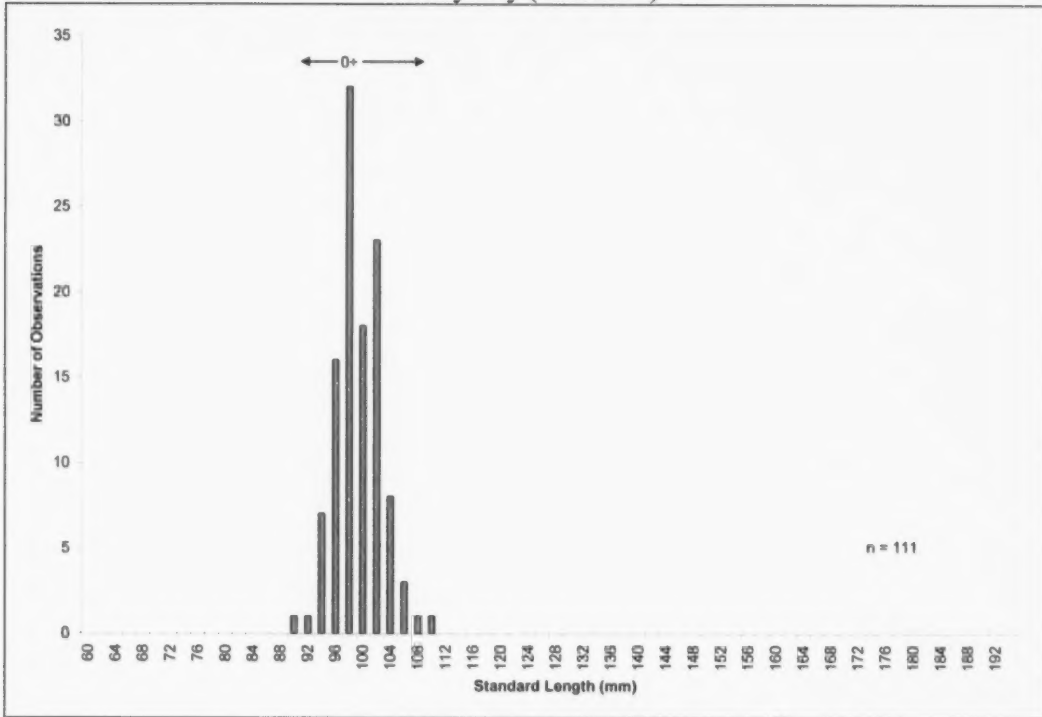


Figure 5. Length-frequency histograms of juvenile herring by transect location for the 2010 Strait of Georgia juvenile herring survey.

Henry Bay (transect 4)



French Creek (transect 5)

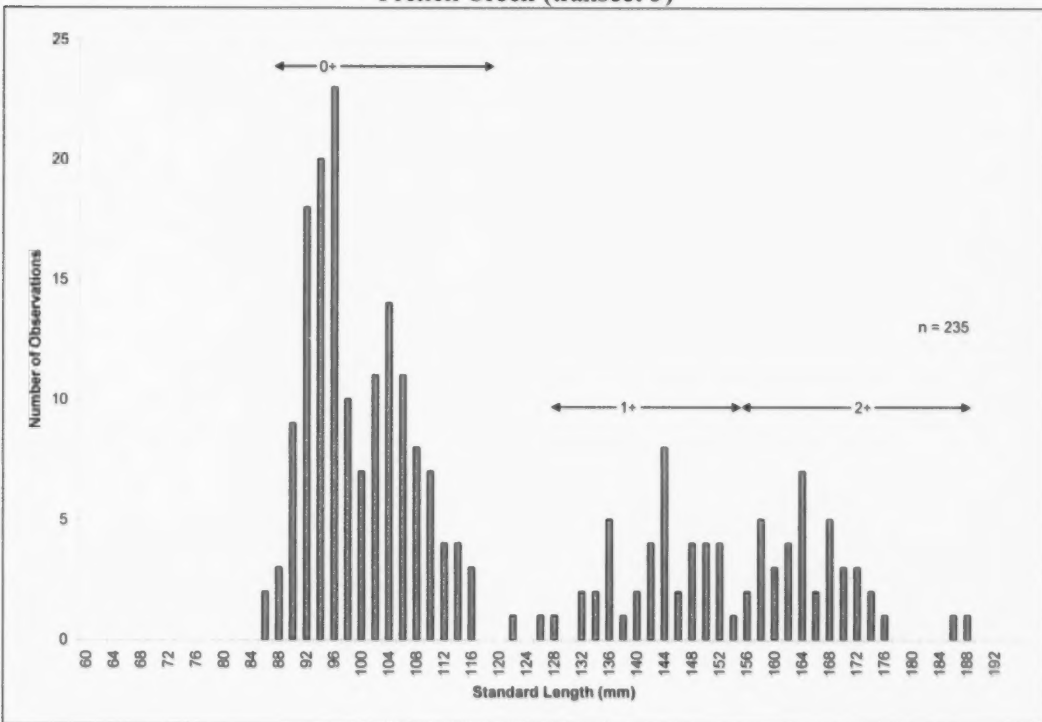
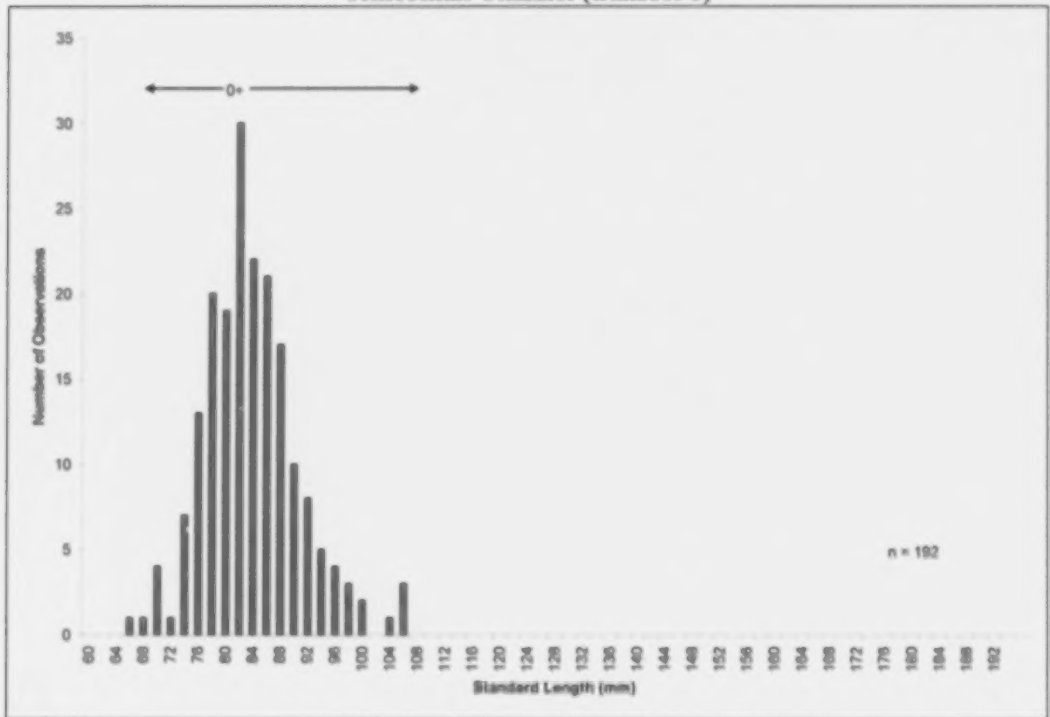


Figure 5...continued

Trincomali Channel (transect 6)



Smelt Bay (transect 8)

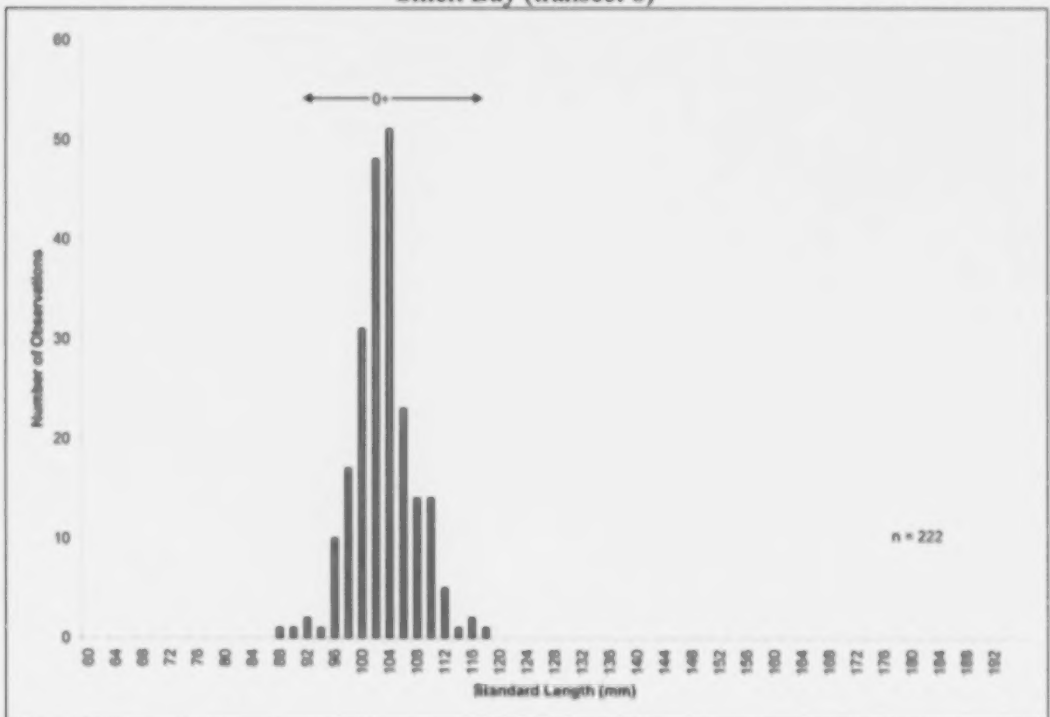
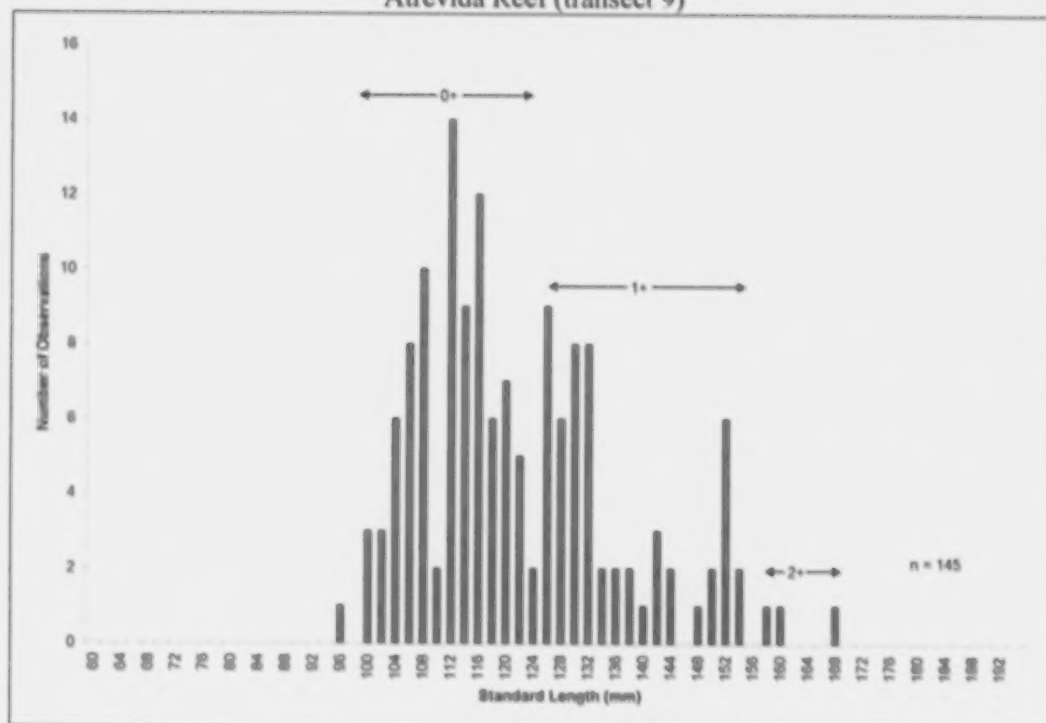


Figure 5...continued

Atrevida Reef (transect 9)



Cape Cockburn (transect 10)

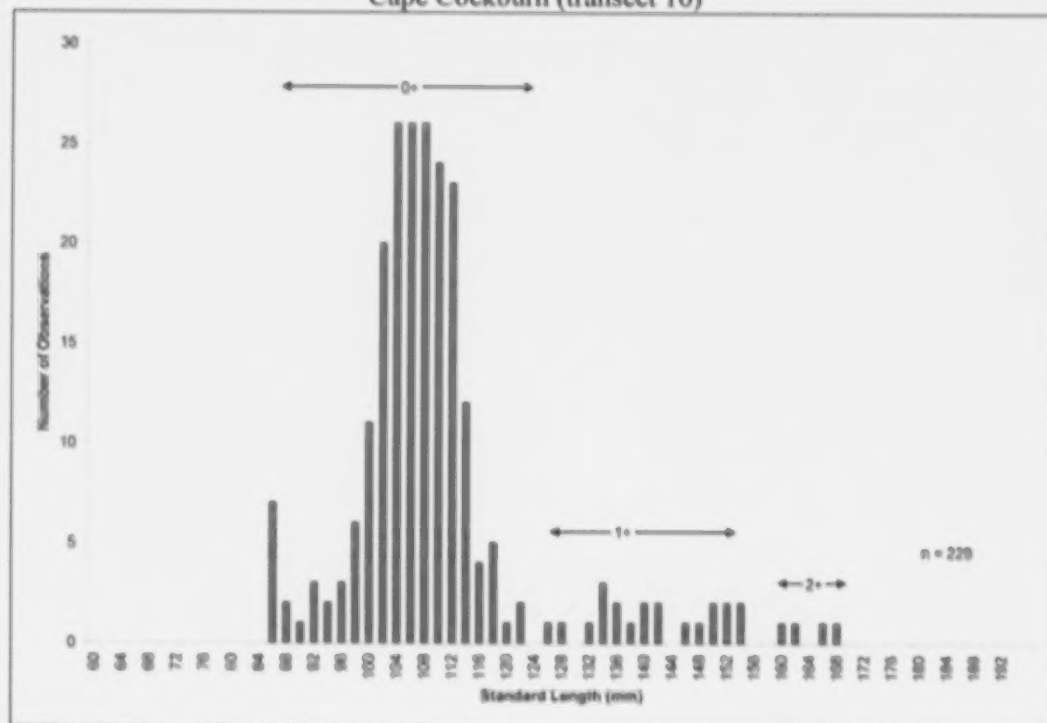


Figure 5...continued

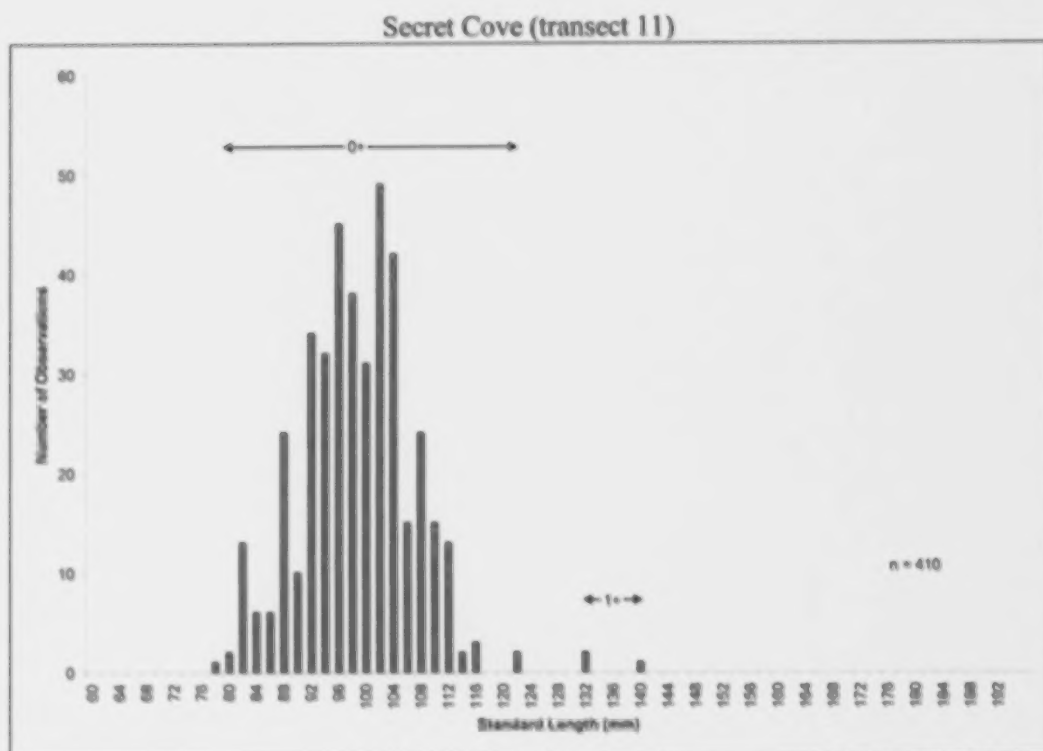


Figure 5...continued

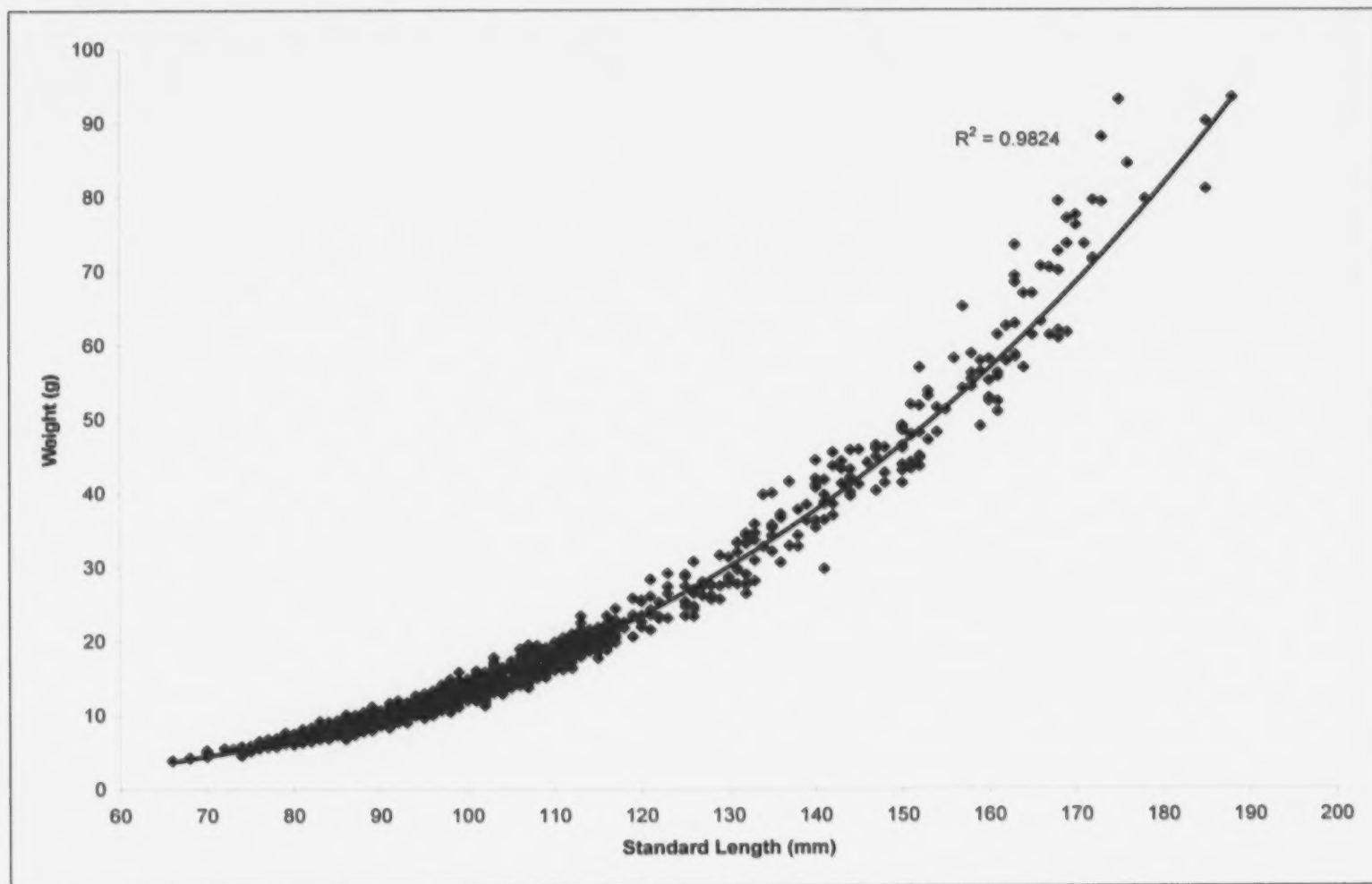


Figure 6. Length-weight relationship for all herring sampled during the 2010 Strait of Georgia juvenile herring survey.

Table 1. Summary of the purse seine set locations from the 2010 Strait of Georgia juvenile herring survey.

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2010	9	12	6	1	2040	Trincomali Channel	48.855	123.430
2010	9	12	6	2	2105	Trincomali Channel	48.862	123.423
2010	9	12	6	3	2125	Trincomali Channel	48.867	123.417
2010	9	12	6	4	2150	Trincomali Channel	48.873	123.407
2010	9	12	6	5	2210	Trincomali Channel	48.877	123.407
2010	9	13	2	5	2040	Yellow Point	49.066	123.698
2010	9	13	2	4	2110	Yellow Point	49.060	123.708
2010	9	13	2	3	2135	Yellow Point	49.056	123.722
2010	9	13	2	2	2155	Yellow Point	49.050	123.733
2010	9	13	2	1	2220	Yellow Point	49.042	123.747
2010	9	14	1	1	2030	Clarke Rock	49.224	123.943
2010	9	14	1	2	2055	Clarke Rock	49.233	123.932
2010	9	14	1	3	2115	Clarke Rock	49.237	123.922
2010	9	14	1	4	2135	Clarke Rock	49.237	123.912
2010	9	14	1	5	2200	Clarke Rock	49.238	123.902
2010	9	16	5	5	2040	French Creek	49.366	124.317
2010	9	16	5	4	2100	French Creek	49.362	124.323
2010	9	16	5	3	2125	French Creek	49.358	124.327
2010	9	16	5	2	2145	French Creek	49.353	124.338
2010	9	16	5	1	2205	French Creek	49.348	124.350
2010	9	19	11	5	2145	Secret Cove	49.523	124.060
2010	9	19	11	4	2215	Secret Cove	49.527	124.040
2010	9	19	11	3	2245	Secret Cove	49.528	124.014
2010	9	19	11	2	2315	Secret Cove	49.532	123.995
2010	9	19	11	1	2340	Secret Cove	49.535	123.977
2010	9	20	10	5	2040	Cape Cockburn	49.632	124.278
2010	9	20	10	4	2110	Cape Cockburn	49.642	124.255
2010	9	20	10	3	2130	Cape Cockburn	49.651	124.242
2010	9	20	10	2	2155	Cape Cockburn	49.662	124.218
2010	9	20	10	1	2225	Cape Cockburn	49.670	124.198
2010	9	21	8	3	2040	Smelt Bay	50.054	125.030
2010	9	21	8	2	2100	Smelt Bay	50.046	125.016
2010	9	21	8	1	2125	Smelt Bay	50.036	125.000
2010	9	21	9	1	110	Atrevida Reef	49.916	124.659
2010	9	21	9	2	130	Atrevida Reef	49.912	124.673
2010	9	21	9	3	155	Atrevida Reef	49.909	124.684

Table 1 continued...

Year	Month	Day	Transect	Station	Seine Set Time	Location Name	DD Lat (N)	DD Long (W)
2010	9	21	9	4	215	Atrevida Reef	49.906	124.694
2010	9	21	9	5	235	Atrevida Reef	49.902	124.707
2010	9	22	4	2	2015	Henry Bay	49.601	124.866
2010	9	22	4	3	2040	Henry Bay	49.598	124.856
2010	9	22	4	4	2055	Henry Bay	49.598	124.846
2010	9	22	4	5	2115	Henry Bay	49.602	124.836
2010	9	28	3	5	2020	Bowser	49.482	124.651
2010	9	28	3	4	2035	Bowser	49.476	124.657
2010	9	28	3	3	2055	Bowser	49.467	124.663
2010	9	28	3	2	2115	Bowser	49.459	124.672
2010	9	28	3	1	2135	Bowser	49.452	124.680

Table 2. Summary of the number and weight by species, transect, and station for 2009 Strait of Georgia juvenile herring survey.

Transect	Station	Location Name	Species	Number	Weight (Kg)*
1	1	Clarke Rock	Chinook salmon	288	18.63
			Juvenile pollock	9	0.10
1	2	Clarke Rock	Chinook salmon	3	0.22
			Chum salmon	1	0.09
1	3	Clarke Rock	Chinook salmon	1	0.08
			Chum salmon	1	0.06
1	4	Clarke Rock	Chinook salmon	1	0.07
			Chum salmon	1	0.06
1	5	Clarke Rock	Chum salmon	1	0.14
			Coho salmon	1	0.26
2	1	Yellow Point	Pacific herring age-0+	670	5.81
2	2	Yellow Point	Pacific herring age-0+	8157	76.68
2	3	Yellow Point	Pacific herring age-0+	11593	102.25
2	4	Yellow Point	Pacific herring age-0+	1859	16.18
			Northern anchovy	26	0.54
2	5	Yellow Point	Pacific herring age-0+	36	0.27
			Northern anchovy	16	0.35
3	1	Bowser	Pacific herring age-0+	262	3.86
			Pacific herring age-1+	26	0.88
			Pacific herring age-2+	24	1.64
			Chinook salmon	6	0.43
			Northern anchovy	2	0.03
			Pink salmon	2	0.11
3	2	Bowser	Pacific herring age-0+	1	0.02
			Chum salmon	2	0.13

* weights \leq 9g referred to as trace

Table 2 continued...

Transect	Station	Location Name	Species	Number	Weight (Kg)*
3	3	Bowser	<i>NO CATCH</i>		
3	4	Bowser	Chum salmon	2	0.18
3	5	Bowser	Chinook salmon	17	1.16
			Chum salmon	7	0.55
4	2	Henry Bay	Pacific herring age-0+	16	0.21
			Midshipman	4	0.01
4	3	Henry Bay	Pacific herring age-0+	2	0.03
4	4	Henry Bay	Pacific herring age-0+	232	3.10
			Gunnel	10	0.06
			Midshipman	6	0.01
4	5	Henry Bay	Pacific herring age-0+	1	0.01
			Gunnel	6	0.03
			Pipefish	3	trace
			Shiner perch	2	0.02
			Midshipman	1	trace
			Three-spine stickleback	1	0.01
5	1	French Creek	Pacific herring age-0+	6	0.11
			Pacific herring age-1+	12	0.52
			Pacific herring age-2+	6	0.64
			Chinook salmon	102	7.01
			Pipefish	6	0.01
			Coho salmon	3	0.29
			Midshipman	3	trace

Table 2 continued...

Transect	Station	Location Name	Species	Number	Weight (Kg)*
5	2	French Creek	Pacific herring age-0+	66	0.81
			Pacific herring age-1+	30	1.10
			Pacific herring age-2+	26	1.72
			Chinook salmon	6	0.41
			Chum salmon	6	0.36
			Midshipman	4	0.10
			Pink salmon	4	0.26
			Gunnel	2	0.02
			Juvenile pollock	2	0.02
5	3	French Creek	Pacific herring age-0+	44	0.61
			Pacific herring age-1+	12	0.53
			Pacific herring age-2+	15	1.01
			Chinook salmon	3	0.23
			Chum salmon	3	0.23
			Coho salmon	2	0.10
			Adult hake	1	0.50
5	3	French Creek	Pacific lamprey	2	0.03
			Pipefish	1	0.00
5	4	French Creek	Pacific herring age-0+	31	0.38
			Pacific herring age-1+	3	0.11
			Pacific herring age-2+	4	0.27
			Chinook salmon	1	0.06
5	5	French Creek	Pacific herring age-0+	45	0.55
			Pacific herring age-1+	7	0.31
			Pacific herring age-2+	4	0.24
			Chinook salmon	3	0.24
			Coho salmon	2	0.30
5	5	French Creek	Pipefish	4	trace
6	1	Trincomali Channel	Pacific herring age-0+	51	0.40
			Sandlance	7	0.01
			Pipefish	1	trace
			Polychaetes		0.10

Table 2 continued...

Transect	Station	Location Name	Species	Number	Weight (Kg)*
6	2	Trincomali Channel	Pacific herring age-0+	17	0.12
			Sandlance	4	0.01
			Chum salmon	3	0.28
			Juvenile smelt	1	trace
			Polychaetes		0.02
6	3	Trincomali Channel	Pacific herring age-0+	9	0.07
			Chum salmon	1	0.08
			Sandlance	1	0.01
6	4	Trincomali Channel	Pacific herring age-0+	15	0.12
			Sandlance	5	0.01
			Chum salmon	2	0.13
6	5	Trincomali Channel	Pacific herring age-0+	354	2.58
			Sandlance	10	0.01
8	1	Smelt Bay	Pacific herring age-0+	1673	25.61
8	2	Smelt Bay	Pacific herring age-0+	444	6.63
			Chinook salmon	6	0.39
8	3	Smelt Bay	Pacific herring age-0+	22	0.30
			Chum salmon	4	0.26
9	1	Atrevida Reef	Chinook salmon	54	3.42
			Chum salmon	12	0.81
9	2	Atrevida Reef	Pacific herring age-0+	45	0.87
			Pacific herring age-1+	5	0.23
			Pacific herring age-2+	5	0.27
			Chinook salmon	80	5.28
			Chum salmon	10	0.68

Table 2 continued...

Transect	Station	Location Name	Species	Number	Weight (Kg)*
9	3	Atrevida Reef	Pacific herring age-0+	17	0.33
			Pacific herring age-1+	28	0.96
			Pacific herring age-2+	1	0.06
			Chinook salmon	8	0.50
			Chum salmon	7	0.39
			Three-spine stickleback	4	trace
9	4	Atrevida Reef	Pacific herring age-0+	60	1.15
			Pacific herring age-1+	40	1.21
			Pacific herring age-2+	2	0.10
			Chinook salmon	10	0.72
			Chum salmon	16	1.04
			Three-spine stickleback	4	trace
			Adult pollock	2	0.09
9	5	Atrevida Reef	Pacific herring age-0+	90	1.70
			Pacific herring age-1+	21	0.60
			Chinook salmon	36	2.40
			Chum salmon	9	0.67
			Juvenile pollock	3	0.02
			Juvenile rockfish	3	trace
			Pipefish	3	trace
10	1	Cape Cockburn	Pacific herring age-0+	1512	24.11
			Pacific herring age-1+	72	3.32
			Pacific herring age-2+	9	0.52
			Juvenile pollock	135	1.20
10	2	Cape Cockburn	Pacific herring age-0+	65	1.11
			Pacific herring age-1+	9	0.36
			Pacific herring age-2+	3	0.20
			Coho salmon	2	0.19
10	3	Cape Cockburn	Pacific herring age-0+	6	0.10
			Pacific herring age-1+	3	0.12
			Chinook salmon	3	0.23
			Juvenile hake	3	0.01
			Pipefish	1	trace

Table 2 continued...

Transect	Station	Location Name	Species	Number	Weight (Kg)*
10	4	Cape Cockburn	Pacific herring age-0+	17	0.20
			Chum salmon	2	0.15
			Northern anchovy	2	0.02
			Chinook salmon	1	0.06
			Pipefish	1	trace
			Sculpin	1	trace
10	5	Cape Cockburn	Pacific herring age-0+	16	0.25
			Pacific herring age-1+	1	0.03
			Pipefish	3	trace
			Chum salmon	1	0.08
11	1	Secret Cove	Pacific herring age-0+	663	6.48
			Northern anchovy	198	0.44
			Chum salmon	3	0.22
			Three-spine stickleback	3	trace
11	2	Secret Cove	Pacific herring age-0+	394	5.48
			Chinook salmon	14	0.95
			Juvenile pollock	8	0.08
			Chum salmon	6	0.49
11	3	Secret Cove	Pacific herring age-0+	17685	252.37
			Pacific herring age-1+	76	2.53
11	4	Secret Cove	Pacific herring age-0+	204	2.65
			Chum salmon	1	0.06
			Coho salmon	1	0.09
			Pink salmon	1	0.08
11	5	Secret Cove	Pacific herring age-0+	8	0.10
			Pacific herring age-1+	2	0.08
			Chinook salmon	2	0.14
			Chum salmon	2	0.19

Table 3. Percent occurrence by species in purse seine sets for the Strait of Georgia juvenile herring survey in 2009.

Species Caught		Percent Occurrence
Common Name*	Scientific Name	2010
Pacific Herring Age-0+	<i>Clupea pallasii</i> young-of-the-year	80.9
Pacific Herring Age-1+	<i>Clupea pallasii</i> in first year	34.0
Pacific Herring Age-2+	<i>Clupea pallasii</i> in second year or more	23.4
Chum salmon	<i>Oncorhynchus keta</i>	51.1
Chinook salmon	<i>Oncorhynchus tshawytscha</i>	44.7
Pipefish	<i>Syngnathus griseolineatus</i>	19.1
Coho salmon	<i>Oncorhynchus kisutch</i>	12.8
Midshipman	<i>Porichthys notatus</i>	10.6
Juvenile Pollock	<i>Theragra chalcogramma</i>	10.6
Sandlance	<i>Ammodytes hexapterus</i>	10.6
Northern Anchovy	<i>Engraulis mordax mordax</i>	10.6
Three-spine Stickleback	<i>Gasterosteus aculeatus</i>	8.5
Gunnel	<i>Apodichthys flavidus</i> or <i>Pholis laeta</i>	6.4
Pink salmon	<i>Oncorhynchus gorbuscha</i>	6.4
Polychaetes		4.3
Sculpin	<i>Leptocottus armatus</i>	2.1
Juvenile Pacific Hake	<i>Merluccius productus</i>	2.1
Shiner Perch	<i>Cymatogaster aggregata</i>	2.1
Juvenile Rockfish	<i>Sebastes</i> sp.	2.1
Adult pollock	<i>Theragra chalcogramma</i>	2.1
Adult hake	<i>Merluccius productus</i>	2.1
Juvenile smelt		2.1
Pacific lamprey	<i>Lampetra tridentatus</i>	2.1
No Catch		2.1

* Squid and jellyfish occurrence is not included due to the large quantities usually encountered and the inability to correctly quantify.

Table 4. Summary of the number of fish sampled, range of length, mean length, range of weight, mean weight, and standard deviations for two herring age classes. Total catch in numbers (N) and weight (Wt) of all herring by transect for the 2010 Strait of Georgia juvenile herring survey.

Age-0+		Number Sampled	Length (mm)			Weight (g)			N	Wt (Kg)
Location Name	Transect		Range	Mean	SD	Range	Mean	SD		
Clarke Rock	1	-	-	-	-	-	-	-	-	-
Yellow Point	2	418	77-112	87	3.95	5.88-17.94	8.83	1.23	22315	201.19
Bowser	3	104	92-120	103	5.39	9.90-25.36	14.65	2.45	263	3.88
Henry Bay	4	111	89-110	99	3.42	10.38-16.53	13.26	1.19	251	3.35
French Creek	5	155	86-121	99	7.44	6.80-23.82	12.82	3.39	192	2.46
Trincomali	6	192	66-105	83	6.93	3.89-15.58	7.48	1.84	446	3.29
Smelt Bay	8	222	88-117	103	4.34	9.75-21.16	14.98	1.82	2139	32.54
Atrevida Reef	9	86	95-122	111	6.19	11.78-25.73	19.09	3.01	212	4.04
Cape Cockburn	10	204	85-122	105	6.97	7.52-28.30	15.93	3.35	1616	25.78
Secret Cove	11	407	77-121	98	7.71	6.61-26.03	12.73	2.93	18954	267.08
All locations		1899	66-122	96	10.13	3.89-28.30	12.38	3.95	46388	543.62

Table 4 continued...

<u>Age-1+</u>		<u>Number Sampled</u>	<u>Length (mm)</u>			<u>Weight (g)</u>			<u>N</u>	<u>Wt (Kg)</u>
<u>Location Name</u>	<u>Transect</u>		<u>Range</u>	<u>Mean</u>	<u>SD</u>	<u>Range</u>	<u>Mean</u>	<u>SD</u>		
Clarke Rock	1	-	-	-	-	-	-	-	-	-
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	13	123-148	133	7.80	26.37-46.12	33.67	5.81	26	0.88
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	41	126-153	142	7.06	26.45-53.08	41.03	6.28	64	2.58
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	-	-	-	-	-	-	-	-	-
Atrevida Reef	9	56	123-154	135	9.57	23.11-48.19	32.27	7.45	94	3.00
Cape Cockburn	10	21	126-154	141	8.69	27.57-56.91	41.71	7.85	85	3.82
Secret Cove	11	3	132-140	135	4.62	33.17-40.70	36.14	4.01	78	2.61
All locations		134	123-154	138	9.10	23.11-56.91	36.65	8.14	347	12.89

Table 4 continued...

Age-2+		Number Sampled	Length (mm)			Weight (g)			N	Wt (Kg)
Location Name	Transect		Range	Mean	SD	Range	Mean	SD		
Clarke Rock	1	-	-	-	-	-	-	-	-	-
Yellow Point	2	-	-	-	-	-	-	-	-	-
Bowser	3	12	159-185	168	8.21	50.98-90.17	68.21	14.01	24	1.64
Henry Bay	4	-	-	-	-	-	-	-	-	-
French Creek	5	39	155-188	165	7.24	48.96-93.39	66.51	11.06	55	3.88
Trincomali	6	-	-	-	-	-	-	-	-	-
Smelt Bay	8	-	-	-	-	-	-	-	-	-
Atrevida Reef	9	3	157-168	162	5.69	52.44-60.88	55.80	4.48	8	0.44
Cape Cockburn	10	4	159-168	164	4.03	57.78-70.58	64.04	7.22	12	0.72
Secret Cove	11	-	-	-	-	-	-	-	-	-
All locations		58	155-188	166	7.24	48.96-93.39	66.14	11.39	99	6.68

Table 5. Grouping of organisms, by phylum with abbreviations from the 2010 plankton tows from the Strait of Georgia juvenile herring survey.

Coelenterata	
COEL	Medusae - <i>Aequorea victoria</i>
SIPH	Siphonophores
Ctenophora	
CTEN	Ctenophores
Annelida	
POLY	Polychaetes
Mollusca	
GAST	Prosobranch gastropods
PELE	Pelecypods
Arthropoda	
AMPH	Amphipods
BARN	Barnacle, unknown stage
CLAD	Cladocerans; <i>Podon</i> sp. and <i>Evadne</i> sp.
CNAU	Unidentified copepod nauplii
COPE	Copepods (see Table 6 for list of species)
CRAM	Crab megalopea, including porcellinadea
CRAZ	Crab zoea, including porcellinadea
CUMA	<i>Cumacea</i> sp.
EUPA	Adult euphausiids; mainly <i>Euphausia pacifica</i>
EUPL	Larval euphausiids; mainly <i>Euphausia pacifica</i>
MYSI	Mysids
OSTR	Ostracods
SHRI	Shrimp zoea
TSPI	<i>Thysanoessa spinifera</i>
Ectoprocta	
ECTO	Ectoprocts; mainly <i>Membranipora</i> sp. larvae
Chaetognatha	
CHAE	Chaetognaths; mainly <i>Sagitta</i> sp.
Chordata	
LARV	Larvaceans; mainly <i>Oikopleura</i> sp.
Miscellaneous	
EGGS	Unidentified eggs; either euphausiid or teleost

Table 6. Abbreviations for calanoid, cyclopoid, harpacticoid and monstrilloid copepods identified in 2010 plankton samples from the Strait of Georgia juvenile herring survey.

Calanoid copepods	
ALON	<i>Acartia longiremis</i>
CABD	<i>Centropages abdominales</i>
CALA	<i>Calanus sp.</i>
CMAR	<i>Calanus marshallae</i>
CPAC	<i>Calanus pacificus</i>
EBUN	<i>Eucalanus bungii</i>
EELO	<i>Eucalanus elongatus</i>
ELON	<i>Epilabidocera longipedata</i>
EUCH	<i>Euchaeta sp.</i>
METR	<i>Metridia sp.</i>
MPAC	<i>Metridia pacifica</i>
OBOR	<i>Oncaea borealis</i>
PPAR	<i>Paracalanus parvus</i>
PSEU	<i>Pseudocalanus sp.</i>
SMIN	<i>Scolecithricella minor</i>
TDIS	<i>Tortanus discaudatus</i>
UCAL	Unidentified or mixed juvenile calanoids
Cyclopoid copepods	
CANG	<i>Corycaeus anglicus</i>
OATL	<i>Oithona atlantica</i>
OITH	<i>Oithona sp.</i>
OSIM	<i>Oithona similis</i>
Harpacticoid copepods	
UHAR	Unidentified Harpacticoid
Monstrilloid copepods	
MONS	<i>Monstrilla sp.</i>

Table 7. Number of zooplankton per m³ of water by set in samples from the 2010 Strait of Georgia juvenile herring survey. Species codes as shown in table 5 and 6.

Location	Tran	Stn	Volume (m ³)	ALON	AMPH	BARN	CABD	CALA	CANG	CHAE	CLAD	CMAR
Clarke Rock	1	1	16.291	0.5	1.6	14.9	-	29.7	2.5	-	6.4	-
		3	19.602	1.2	1.3	0.1	1.2	57.7	8.6	0.2	0.8	-
Yellow Point	2	1	13.127	-	0.1	24.5	-	93.4	74.3	-	39.0	-
		4	14.389	-	-	89.0	-	1289.9	44.5	-	8.9	-
Bowser	3	1	16.431	-	0.7	4.6	-	1.2	2.2	0.1	5.8	-
		4	19.444	1.6	0.3	1.6	-	92.5	21.4	0.2	-	-
Henry Bay	4	1	10.438	3.1	1.9	70.5	-	39.6	79.7	-	751.1	-
		3	6.050	42.3	3.0	190.4	-	290.9	317.4	-	1586.8	-
French Creek	5	1	10.163	6.3	1.7	11.0	-	1.4	6.3	-	310.1	-
		3	13.424	1.2	1.8	0.7	-	9.8	1.8	-	12.5	-
Trincomali	6	1	10.163	-	2.2	394.0	-	55.8	5.4	-	-	3.6
		3	13.424	-	-	126.2	-	26.2	20.7	0.1	25.9	-
Smelt Bay	8	1	20.608	31.2	2.6	62.1	-	102.1	15.5	-	633.5	-
		2	19.719	45.4	-	32.5	16.2	393.3	45.4	-	412.2	-
Atrevida Reef	9	1	16.637	-	0.1	0.5	-	3.6	1.9	-	-	-
		3	19.549	8.2	-	-	1.6	93.7	1.6	0.8	-	-
Cape Cockburn	10	3	17.050	5.6	2.8	-	-	23.3	3.8	0.9	-	-
		5	18.963	11.8	6.9	-	-	37.0	1.7	-	-	-
Secret Cove	11	1	13.418	1.8	0.9	2.5	-	1.6	3.3	-	-	-
		3	17.459	0.5	1.4	0.1	-	18.4	0.5	-	-	-

Table 7 continued...

Location	Tran	Stn	CNAU	COEL	CPAC	CRAM	CRAZ	CTEN	CUMA	EBUN	ECTO	EELO	EGGS
Clarke Rock	1	1	-	0.5	-	-	0.6	-	0.1	-	0.5	-	-
		3	-	-	0.1	0.1	0.1	0.1	-	0.1	-	-	7.3
Yellow Point	2	1	-	1.7	0.7	-	7.8	0.2	-	-	-	-	41.4
		4	-	46.7	553.8	2.2	-	-	-	-	-	-	-
Bowser	3	1	-	0.1	-	-	0.1	-	-	-	8.5	-	-
		4	-	-	16.4	-	0.1	-	-	-	-	-	-
Henry Bay	4	1	-	2.6	-	2.7	32.3	-	-	-	3.1	-	-
		3	-	2.1	-	2.0	11.6	-	-	-	-	-	-
French Creek	5	1	7.9	-	-	0.2	2.4	0.2	-	-	-	-	-
		3	-	0.6	0.3	0.2	0.1	0.1	-	0.1	-	-	-
Trincomali	6	1	-	5.3	27.0	-	5.4	-	-	-	-	-	-
		3	-	0.5	0.1	0.1	0.9	0.1	-	-	-	-	-
Smelt Bay	8	1	-	2.7	0.1	0.2	4.0	2.3	-	-	3.1	-	3.1
		2	-	0.3	2.4	0.6	3.7	-	-	-	-	-	0.1
Atrevida Reef	9	1	-	3.8	-	0.1	-	0.1	-	-	1.4	-	-
		3	-	-	8.2	-	0.4	-	-	-	-	-	-
Cape Cockburn	10	3	-	-	9.4	-	-	-	-	-	-	0.5	-
		5	-	-	0.1	-	-	-	-	-	-	-	-
Secret Cove	11	1	-	0.8	0.2	-	-	-	0.1	-	-	-	0.6
		3	-	0.1	1.0	0.1	-	-	-	-	-	-	-

Table 7 continued...

Location	Tran	Stn	ELON	EUCH	EUPA	EUPL	GAST	LARV	MONS	MPAC	MYSI	OATL	OBOR
Clarke Rock	1	1	-	-	-	-	-	5.9	-	-	-	-	-
		3	-	-	-	1.2	0.8	-	-	-	-	28.2	-
Yellow Point	2	1	0.1	-	-	10.1	-	8.5	-	-	-	-	-
		4	-	-	-	-	8.9	8.9	-	-	-	-	-
Bowser	3	1	-	-	-	0.2	3.4	21.2	-	3.0	-	9.7	0.2
		4	-	-	-	1.3	1.6	-	-	34.8	-	31.3	-
Henry Bay	4	1	-	-	-	-	33.7	64.4	-	-	0.2	-	-
		3	-	-	-	-	84.6	232.7	-	-	-	-	21.2
French Creek	5	1	-	-	-	-	25.2	104.0	-	-	-	9.4	-
		3	-	-	-	0.7	8.3	32.8	-	0.1	-	13.7	-
Trincomali	6	1	3.4	-	-	-	0.2	27.0	-	1.8	-	-	-
		3	0.1	-	-	1.7	12.1	79.5	-	0.1	0.1	-	-
Smelt Bay	8	1	0.2	-	trace	-	24.8	-	-	0.1	0.1	-	-
		2	-	-	-	2.3	-	-	-	0.1	-	-	6.5
Atrevida Reef	9	1	-	-	-	0.1	5.8	2.9	-	0.8	-	2.4	-
		3	-	0.9	-	24.0	4.9	3.3	-	37.3	-	-	3.3
Cape Cockburn	10	3	-	-	70.4	6.1	5.6	-	-	37.1	-	5.6	-
		5	-	-	0.8	0.1	1.7	1.7	-	2.6	-	-	1.7
Secret Cove	11	1	-	-	0.4	0.4	1.2	31.3	0.1	-	0.3	-	-
		3	-	-	4.6	2.9	-	4.1	-	5.8	-	-	-

trace = $\leq 0.04 \text{ m}^3$

Table 7 continued...

Location	Tran	Stn	OITH	OSIM	OSTR	PELE	POLY	PPAR	PSEU	SHRI	SIPH	SMIN	TDIS
Clarke Rock	1	1	56.5	-	-	-	2.0	30.3	11.9	2.8	-	-	2.3
		3	-	-	0.8	-	0.1	7.3	42.5	0.2	0.1	0.4	-
Yellow Point	2	1	-	14.6	-	-	11.0	6.0	-	5.8	12.4	-	-
		4	-	8.9	-	-	-	8.9	17.8	2.2	-	-	-
Bowser	3	1	-	16.1	-	-	-	5.4	2.6	-	1.9	-	-
		4	-	-	-	-	-	4.9	36.2	0.2	1.7	5.0	-
Henry Bay	4	1	-	27.6	-	-	24.7	114.0	16.3	14.8	4.6	-	29.4
		3	-	528.9	-	21.2	63.8	856.9	253.9	61.2	23.1	-	58.2
French Creek	5	1	-	61.4	-	-	-	14.0	17.6	14.2	1.9	4.7	-
		3	-	20.9	-	-	-	6.0	14.3	2.3	0.8	-	-
Trincomali	6	1	3.6	-	0.2	-	9.0	0.9	94.1	2.5	-	-	1.1
		3	-	10.4	-	-	15.5	38.0	26.7	2.0	-	-	3.5
Smelt Bay	8	1	-	49.7	0.1	-	9.3	74.7	40.7	5.4	14.5	-	-
		2	-	35.7	3.2	-	9.7	97.4	66.0	13.3	30.1	-	-
Atrevida Reef	9	1	-	12.5	-	-	-	20.9	23.8	15.9	0.2	0.5	-
		3	-	26.2	-	-	-	97.2	178.1	1.2	-	-	-
Cape Cockburn	10	3	-	22.5	9.4	-	6.6	18.8	179.8	1.9	-	-	-
		5	-	37.1	1.7	-	-	41.3	253.1	1.7	-	-	-
Secret Cove	11	1	-	6.3	-	-	-	3.9	5.8	3.0	-	-	-
		3	-	5.5	-	-	-	7.3	36.5	0.1	-	0.5	-

Table 7 continued...

Location	Tran	Stn	TSPI	UCAL	UHAR
Clarke Rock	1	1	-	0.1	-
		3	-	-	-
Yellow Point	2	1	-	-	-
		4	-	-	-
Bowser	3	1	-	0.1	-
		4	-	-	-
Henry Bay	4	1	-	0.2	-
		3	-	1.0	-
French Creek	5	1	-	-	-
		3	0.4	-	-
Trincomali	6	1	-	-	-
		3	-	-	-
Smelt Bay	8	1	-	-	-
		2	-	-	-
Atrevida Reef	9	1	-	0.1	-
		3	-	-	-
Cape Cockburn	10	3	-	-	1.9
		5	0.5	-	-
Secret Cove	11	1	0.7	-	-
		3	-	-	-